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DATED this 11 day of October, 2004



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Throughout his career, Dr. Rodney M. LaFollette has worked on high efficiency designs of secondary batteries and fuel cells, especially bipolar designs. Funded research activities over the past ten years include lithium/lithium peroxide solid state batteries, bipolar silver/zinc batteries, several types of bipolar lead acid batteries, including an effort funded by General Motors/Department of Energy to build a bipolar lead acid battery for use in hybrid vehicles. Further funded efforts include microscopic batteries for use in MEMS and other integrated circuits, remote autonomous sensors, fuel cells, and capacitors. Dr. LaFollette also has extensive experience with mathematical modelling of batteries, including the development of a model of spirally-wound lead acid batteries used in the Hybrid Vehicle Program at General Motors. Dr. LaFollette has served as Principal Investigator on research contracts and grants totaling over \$4M over the past 13 years.

Employment

1992 – Present President/Founder, Bipolar Technologies Corp., Provo, UT
1990 – 1992 Vice President of Engineering, Enyon Corp., Provo, UT
1987 – 1990 Senior Materials Eng., International Fuel Cells, South Windsor, CT

Education

Academic Diploma, International School of Brussels, Brussels Belgium, 1975
B.S., M.S., Chemical Engineering, Brigham Young University, 1984
Ph.D., Chemical Engineering, Brigham Young University, 1988

Professional/Honor Societies Areas of Expertise

Tau Beta Pi, Sigma Xi, Mathematical Modeling,
Electrochemical Society, AIChE Electrochemistry, Colloid Chemistry,

Publications

LaFollette, R., Hedman, P., Smith, P., "Analysis of Two-Color Coal Particle Temperature Measurements," *Combustion Science and Technology*, 66, p. 93 (1989).
Ashley, K., Parry, D., Harris, J., Pons, S., Bennion, D., LaFollette, R., Jones, J., King, J., "Properties of Electrochemically Generated Poly(p-Phenylene), *Electrochimica Acta*, 34, No. 5, 599 (1989).
LaFollette, R., Bennion, D., "Design Fundamentals of High Power Density, Pulsed Discharge, Lead Acid Batteries I. Experimental," *J. Electrochem. Soc.*, 137, No. 12, 3693 (1990).
LaFollette, R., Bennion, D., "Design Fundamentals of High Power Density, Pulsed Discharge, Lead Acid Batteries II. Modeling," *J. Electrochem. Soc.*, 137, No. 12, 3701 (1990).
LaFollette, R., "Design and Performance of High Specific Power, Pulsed Discharge, Bipolar Lead Acid Batteries," *Proceedings of the Tenth Annual Battery Conference on Applications and Advances*, Long Beach, CA, p. 43, January (1995).
Stewart, L., Bennion, D., LaFollette, R., "Mathematical Model of the Anodic Oxidation of Lead," *J. Electrochem. Soc.*, 141, No. 9, p. 2416 (1994).
Ryan, D., LaFollette, R.M., Salmon, L., "Microscopic Batteries for Micro ElectroMechanical Systems (MEMS)," *Proceedings of 32nd IECEC*, 97-8, 97136, Honolulu, HI, August (1997).
LaFollette, R.M., Salmon, L.G., Barksdale, R.A., Beachem, B., Harb, J.N., Holladay, J.D., Humble, P.H., Ryan, D.M., "The Performance of Microscopic Batteries Developed for MEMS Applications," *Proceedings of 33rd IECEC*, 98-8, Colorado Springs, CO, August (1998).
Harb, J., LaFollette, R.M., "Predictions of Thermal Behavior of a Spirally-wound Lead-Acid Battery," *Proceedings of 33rd IECEC*, 98-8, Colorado Springs, CO, August (1998).
Salmon, L.G., Barksdale, R.A., Beachem, B.R., Harb, J.N., Holladay, J.D., Humble, P.H., LaFollette, R.M., Ryan, D.M., "Fabrication of Rechargeable Microbatteries for Microelectromechanical Systems (MEMS) Applications," *Proceedings of 33rd IECEC*, 98-8, Colorado Springs, CO, August (1998).
Salmon, L.G., Bardsdale, R.A., Beachem, B.R., LaFollette, R.M., Harb, J.N., Holladay, J.D.,

Humble, P.H., "Development of Rechargeable Microbatteries for Autonomous MEMS Applications," Proceedings of the Solid State Sensor & Actuator Workshop, Hilton Head, SC (1998).

Salmon, L.G., Barksdale, R.A., Beachem, B.R., Harb, J.N., Holladay, J.D., Humble, P.H., LaFollette, R.M., Ryan, D.M., "Fabrication of Rechargeable Microbatteries for Microelectromechanical Systems (MEMS) Applications," *Proceedings of 33rd IECEC, 98-8*, Colorado Springs, CO, August (1998).

Harb, J., LaFollette, R.M., "Mathematical Model of the Discharge Behavior of a Spirally Wound Lead-Acid Cell," *J. Electrochem. Soc.*, **146**, No. 3, p. 809 (1999).

Ryan, D., LaFollette, R.M., Harb, J.N., "Power Supply Concepts for Remote, Autonomous Sensors," *SAE Proceedings 1999*, Phoenix, AZ, April (1999).

Harb, J.N., Holladay, J.D., Humble, P.H., Barksdale, R.A., Crop, T., Anderson, B.A., Salmon, L.G., Ryan, D.M., LaFollette, R.M., "Electrochemical Behavior of Microscopic Secondary Batteries," Proceedings of 34th IECEC, 99-8, Vancouver, B.C. (1999).

LaFollette, R.M., Harb, J.N., Humble, P.H., "Microfabricated Secondary Batteries for Remote, Autonomous Electrical Devices," Proceedings of the 16th Annual Battery Conference on Applications and Advances, IEEE 01TH8533, Long Beach, CA, p. 349 (2001).

Rajagopalan, J., Singh, P., LaFollette, R., Reisner, D., "Architecture and Preliminary Design of a Fuzzy Logic-Based Microbattery Charge Controller," Proceedings of the 16th Annual Battery Conference on Applications and Advances, IEEE 01TH8533, Long Beach, CA (2001).

Ryan, D.M., LaFollette, R.M., "Power Supply and Energy Storage Options for Autonomous MEMS," *SAE Proceedings 2001*, October (2001).

Humble, P.H., Harb, J.N., LaFollette, R.M., "Microscopic Nickel-Zinc Batteries for Use in Autonomous Microsystems," Journal of the Electrochemical Society, **148**, No. 12, p. A1357 (2001).

Harb, J.N., LaFollette, R.M., Selfridge, R.H., Howell, L.L., "Microbatteries for Self-Sustained Hybrid Micropower Supplies," Journal of Power Sources, **104**, Issue 1, p. 46 (2002).

Singh, P., Rajagopalan, J., LaFollette, R., Fennie Jr., C., Reisner, D.E., "Fuzzy-Logic Charge Controller for Microbatteries," Proceedings, 28th IEEE Conference (2001).

LaFollette, R., Singh, P., Broadhead, J., Reisner, D., "Development of a Fuzzy-Logic Managed Microscopic Battery," IEEE Proceedings, Sensors 2002 Conference, Orlando, FL, June 12-14, (2002) (Invited Paper).

Patents

1. Bennion D.N.; LaFollette R.M.; Stewart L.L., "Electrochemical System using Bipolar Electrode." U.S. 5,536,598, 25 Aug, 1992.
2. LaFollette R.M., "Bipolar Battery Cells, Batteries and Methods," U.S. 5,536,598, Jul 16, 1996.
3. LaFollette R.M., "Bipolar Battery Cells, Batteries and Methods," U.S. 5,556,627, 17 Sept, 1996.
4. LaFollette R.M., "Methods of making Bipolar Battery Plates comprising Carbon and Fluoroelastomer," U.S. 5,582,622, 10 Dec, 1996.
5. LaFollette, R.M., "Bipolar Battery Cells, Batteries and Methods," U.S. 5,582,937, 10 Dec 1996.
6. LaFollette, R.M., "Source of Electrical Power for an Electric Vehicle and Other Purposes and Related Methods," U.S. 6,063,525, 15 May, 2000.
7. LaFollette, R.M., "Source of Electrical Power for an Electric Vehicle and Other Purposes and Related Methods," U.S. 6,479,179, 25 Aug, 2002.
8. LaFollette, R.M., Salmon, L.G., Harb, J.H., "Microscopic Batteries for MEMS Systems," U.S. 6,610,440B1, 26 August, 2003.

Several Others pending or in submission



Mark Philbrick/Brigham Young University

Brigham Young professor Linton Salmon is reflected in a wafer that he helped invent. It contains 1,200 batteries.

Honey, I shrunk the battery

BY DAN NAILEN

THE SALT LAKE TRIBUNE

Computer researchers are not only building better gadgets as technology advances, but making them smaller, faster and cheaper.

Microelectromechanical systems, or MEMS, have dominated the work of many researchers and engineers in recent years. MEMS are a series of miniature electronic structures and sensors integrated on one silicon chip. They range in size from less than one inch to a micron — one-thousandth the thickness of a nickel.

MEMS are not only compact, but usually are more precise than older systems due to the close proximity of their parts. They are already used commercially in automobile air bags, with a tiny MEMS sensor triggering the bag when it senses a rapid change in motion. More potential applications pop up every day.

Now a Brigham Young University engineer wants to give MEMS systems their own power source.

Linton Salmon, BYU's associate dean of engineering and technology, supervised MEMS research for the National Science Foundation in the early 1990s. During his NSF tenure, Salmon noticed dozens of grant seekers developing MEMS. He also noticed most of the projects had to be energized by outside power sources, mainly batteries several times the size of the MEMS chip itself.

"For a lot of electrical engineers, power is just something you buy the battery (for)," Salmon said. "They build sensors, then go looking for batteries to fit."

When he returned to BYU, Salmon decided to create a microbattery capable of fitting inside MEMS. After several trial runs, he and his colleagues have created a design they believe could revamp MEMS.

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Batteries: The Shrinking Power Source

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Next week, Salmon will present his group's findings to the Solid-State Sensors and Actuator Workshop, a leading MEMS industry forum meeting in Hilton Head, S.C. The conference has been held every other year since 1984 and is limited to 300 researchers, all actively working with MEMS.

Most MEMS industry scientists are either electrical engineers or mechanical engineers, Salmon said, "but batteries are a chemical thing, and we needed chemical engineers" to build a MEMS battery. Salmon's microbattery is made of a nickel and zinc compound, and includes a tiny, tightly sealed reser-

voir of liquid electrolytes to supply the needed power. It is built with the same processes used to make computer chips, he added, including "extremely small dimensions and extremely pure materials."

The entire microbattery is only as thick as a strand of human hair and is the same size as the circuits on the MEMS silicon chips, Salmon said. The design is intended to enable MEMS producers to eventually include the microbattery internally in their products.

"The question," Salmon said, "is how much energy can it put out for how long?"

Salmon sees the microbattery potentially used in conjunction with miniature timers. Since the various sensors on a MEMS chip do not need to be powered up at all times, the timer can send the microbatteries a message to turn on at specific intervals. In turn, the microbatteries would power the sensors to activate and send data, using radio signals, to a remote central computer.

The microbatteries are rechargeable as well; Salmon said, and a MEMS chip could potentially function indefinitely with a small solar cell, timer and one of the new microbatteries.

Some day in the near future, he said, a house thermostat could cost significantly less if it includes a microbattery instead of being wired to a power source and a furnace. A timer-rigged microbattery could power the MEMS sensors measuring the temperature, which would then send the measurements by radio wave to a central computer at assigned intervals.

Once Salmon and other researchers determine how much energy can be stored in a microbattery, the tiny power sources could be used to monitor vital signs in trauma victims, or power the pumps regulating insulin flow in diabetics. The batteries could even be used to power sensors that measure automobile tire or engine wear, sending radio messages to the car's onboard computer at

scheduled times.

Robert Huber is a professor of electrical engineering at the University of Utah and a member of the organizing committee for the Hilton Head conference. He said Salmon's research was selected for the conference because "it's high quality work, it's a novel idea and has the possibility of having a lot of uses."

Huber, who has been attending the MEMS conferences since 1986, is quick to note that all the ideas presented at Hilton Head are in the early stages of research. The microbattery and other potential products are still speculative, he said.

"How much energy can you really store?" Huber asked of the microbattery. "That remains to be seen."

Salmon and the BYU research team plan to commercialize their microbattery through Bipolar Technologies, an Orem-based battery manufacturer.